NEAR EAST UNIVERSITY

Faculty of Engineering

Department of Biomedical Engineering

DESIGN OF PROTON BASIC BASED ELECTROCAUTERY TIME MEASUREMENT AND DISPLAY SYSTEM

Graduation Project
BME – 400

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ABSTRACT

This project is about the design and development of a microcontroller based electrocautery time measurement and display system. The designed system is connected to a standard electrocautery device with two foot pedals. The device measures the duration of each pedal pressed during an operation. The measured values are displayed on a two-line LCD. The displayed values could help the consultant and the anesthetist to have an idea of the amount of CO gas released and consequently to adjust the amount of anesthesia to be given to the patient. With the help of this device, early precaution can be taken to keep the patient in good health.

The project describes the theory of electrocautery briefly and then gives details of the microcontroller based measurement and display system designed and developed by the author.

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INTRODUCTION

Electrocautery is a surgical technique which involves introducing high frequency current to a specific area of the body in order to remove unwanted tissue, seal off blood vessels, or to create a surgical incision. Many surgeons use electrocautery instruments, under the belief that electrocautery is cleaner, safer, and more efficient than many of the alternatives.

The aim of this project is to design a microcontroller based system in order to measure and display the time that each foot pedal is pressed in an operation. The designed and developed device is called a “counter” in this project.

Electrocautorization is very simple technique for surgeons. However, electrocautorization causes deformations of the tissues which cannot be repaired. To minimize these tissues deformations, a counter was designed by the author to measure and display the foot pedal usage during an operation. Thus surgeons can control themselves and minimize the using time for every same operation and they can minimize tissue deformations.

During laparoscopic operation by using electrocautery, CO gas is released. This released CO penetrates into arteries and is normally attached to hemoglobin in the blood. This is a side effect for electrocotery usage in operations. When the amount of CO is large, the anesthetist pumps O_2 gas to the patient minimize this side effect.

With the help of the designed counter, the anesthetist can see when the electrocautery using and pump oxygen how much the patients need.

The author has carried out a literature search to find out if there are similar devices in the market place. But unfortunately, although there are many types of electrocautery devices, none of these devices seem to have timers to measure and display the durations of pedal movements.

This project includes three chapters. Chapter one explains the definition, types, features and effects of electrocautery.

Chapter two presents the electrosurgical units which included definition and features of it. Chapter three shows the project software and hardware. Finally, the conclusion part presents the important results obtained within the project.

CHAPTER ONE

ELECTROCAUTERY

1.1 Definition of Electrocautery

Electrocautery device is the simplest electronic system that is used in the operating rooms in the recent era. With the help of batteries in the device, it produces DC current which runs inside the tissue and current heats the string on the edge point. It is used for controlling the simple bleedings.

Cells do not react to the presence of this current since the polarity of the current changes very fast. The current that used in electrosurgery changes between 200 KHz and 3.3 MHz.

The definition of Electrocautery and cautery is used for every kind of electrocautery devices however; this situation is not simply true for each and every case. The only thing that should appear in mind should be cauterization, when the electrocautery is on the agenda. The unit that turns low frequency alternative current into high frequency level of electrosurgery is called generator.

Figure 1: Electrocautery

1.2 Types of Electrocautery

Electrocauteries are divided into two types: one of them is the bipolar electrocautery, and the other is the monopolar electrocautery. The explanation of the types of electrocautery is given below.

1.2.1 Bipolar Electrocautery

This type of electrocautery is based on the fact that, two parallel poles that are very close to each other complete electricity current in the circuit. Required effect is obtained by using very low current since the poles are very close to each other. Since the current appear between two poles, current does not pass through body and the “turn back electrodes” that the current would come back into, will not be in use. Homeostasis could be obtained without appearance of burning areas (harmed area of tissue) since low voltage wave formation is used. Generally, edge points of tissue clamps are used as parallel poles. Bipolar electrosurgery is used very commonly because it is very safe to use.

Figure 2: Bipolar electrocautery

1.2.2 Monopolar Electrocautery

This is the most commonly used system in electrosurgery since it creates wide range of effects on the tissue. The current that created, transmitted by active electrode system and the current that goes through tissue gathered safely by “turn back electrode” from the patient would turn back to device.

In order to obtain required surgical consequences, heat would come into existence, both in the cases of monopolar conduction and bipolar conduction. When the current at the certain area condensed, heat existence could be obtained and the amount of heat would define the effects that would come into existence. The effect that would occur in the tissue would be in direct proportion with the amount of current that appears on certain unit. A condensed current in a certain small area would lead to a high level of resistance, as a result; higher level of heat would come into existence. For a wider certain area, the conclusion would be the opposite of the case that mentioned above.

Figure 3: Monopolar electrocautery

1.3 Feature of Electrocautery

1.3.1 Electrosurgical Cutting

Intensive form of continuous-wave current makes intracellular fluid of tissue boil and leads to degradation of cell structure, and with that situation electrosurgical cutting could be possible.

Low voltage current has high speed and since the current is continuous, in the low voltage levels, vaporization which is required surgical effect could be obtained easily on the tissue. In order to carry out the cutting process, active electrode should be slightly above the targeted tissue. As a result of vaporization of cells by current, it is possible to obtain clean surgical incision. The cutting mode of generator could be used to obtain coagulation by using desiccation process as well.

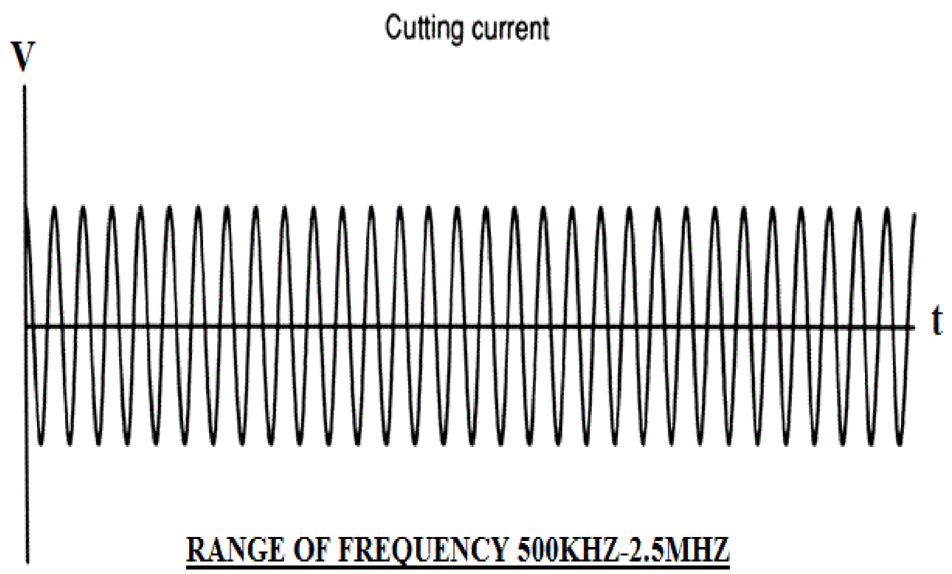


Figure 4: Cutting wave form of electrocautery.

1.3.2 Coagulation

Coagulation occurs at higher current densities than are used in desiccation, resulting in higher tissue temperatures. The tissue fluids boil away and the proteins become denatured, forming a white coagulum similar to that produced when an egg white is boiled. There is loss of cellular definition as all tissue structures fuse into a formless, homogenous mass with a hyalinized appearance. This is the classic appearance of coagulation necrosis.

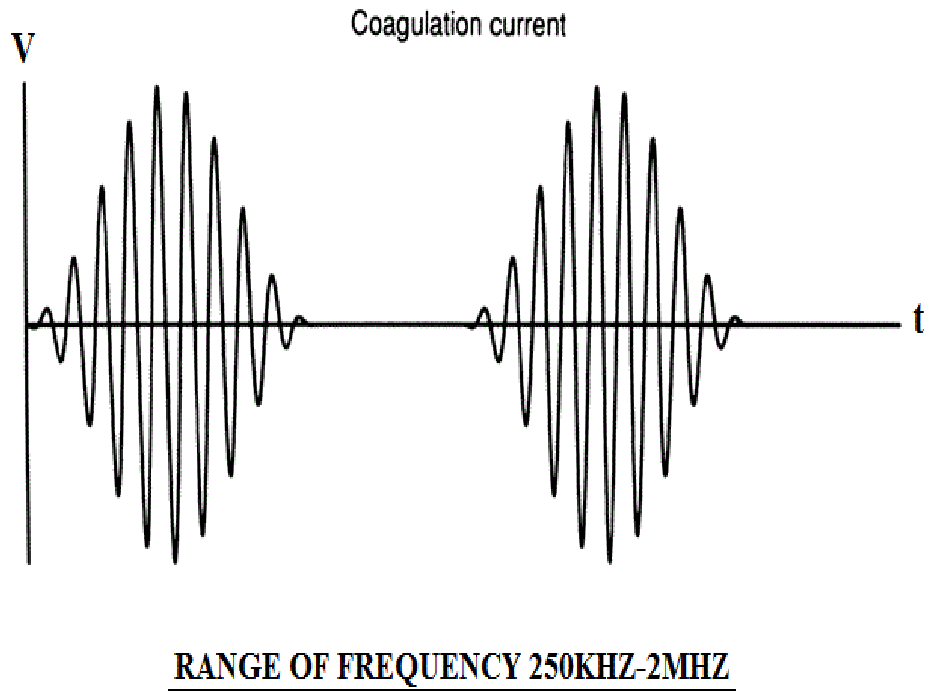


Figure 5: Coagulation wave form of electrocautery.

1.3.3 Fulguration

It is the process in which coagulation process actualized on the tissue by using electrical sparks. The sparks reach to the tissue by leaping from electrode to tissue. Fulguration of tissue could be achieved during the coagulation function of the generator. The point that should be taken into account is that, the sparkle should leap to the tissue without contact of electrode with tissue.

1.3.4 Desiccation

It is the process in which the surgical effect occurs as dehydration and protein denaturation on the tissue as a result of contact of electrode with the tissue. Lower level of current would be in use compare to the cutting process, which is mentioned above. Desiccation could be obtained through cutting mode or coagulation functions of generator. Because of the fulguration difference edge point of the electrode should be in contact with the tissue.

1.3.5 Vaporization

The cutting of tissue by electrical current is due to the vaporization of cells. This is a special and interesting case, since the actual mechanisms of cutting remain controversial. As with the other tissue effects, the cutting action of electrical current is a product of current density. A dampened (coagulating) current can be made to divide tissue (albeit at the expense of great lateral thermal damage) by increasing the power or decreasing the electrode size, and an undamped, sinusoidal current (cutting) will produce coagulation if the current density is low, and the electrode contacts tissue. Every gynecologist who has performed tubal sterilization with the Wolf bipolar unit has made use of cutting current to produce coagulation of tissue.

Cutting tissue requires that a spark be present between the electrode and the tissue. An arc may be present in coagulating currents, and is necessary in fulguration. In the formation of an arc, little happens until a sufficient voltage is reached to allow the electrons to traverse the air gap between electrode and tissue. When this voltage is reached, electrons jump across the gap, causing ionization of the air molecules along the path of the spark. This ion path presents a low resistance pathway to the tissue, so long as the plasma (gas composed of ionized molecules) cloud is maintained. In a cutting current, the rapidly repetitive peak voltages occur before the plasma cloud can dissipate, so that each spark tends to follow the same pathway, maintaining ionization of the air along the spark path and striking the tissue at the same spot, generating a locally high current density. A dampened current reaches higher peak voltages than does an undamped one, but the peaks are separated by a longer period of time so that the plasma cloud dissipates between each peak. The low resistance path to tissue is lost, and the charring and dehydration of the tissue caused by the previous spark cause a locally higher resistance, decreasing the likelihood of a subsequent spark striking the same spot. The net result is a lower current density, and coagulation. McLean demonstrated the essential difference between the arcs used in cutting and the other effects by photographing the sparks caused by damped and undamped currents and found that the former caused a broad, brush like spark (low current density), while the latter caused a tight, pencil-like arc (high current density).

It is thought that the cutting effect on tissue stems from the extremely high localized current density causing boiling of the intracellular water, and exploding the cells. Lateral damage is minimized by heat being carried off by the steam.

Pearce postulated a second mechanism of cellular disruption. When an intense electromagnetic field impinges on an absorbing tissue, the rate of vapor formation cannot keep up with the rate of energy input. To maintain thermodynamic equilibrium, an acoustic wave is generated, disrupting the cell. This may account for the description by Eisenmann and co-workers of an individual mast cell divided without disturbance of the intracellular structures.

The degree of tissue damage caused by electrical energy is determined by numerous factors in addition to waveforms and current density. The electrical resistance of the tissue is important as is the inherent sensitivity of the tissue to damage by heat. Maness and associates found that epithelium is more sensitive to damage than is connective tissue or muscle in hamster tongue. Luciano and colleagues found that, in rabbits, the ovary was less susceptible to damage than the uterus.

The degree of tissue damage is also affected by the duration of the energy application, with increasing levels of damage being seen with longer applications. The rate of tissue destruction, however, decreases with increasing duration of application; after the resistance of the destroyed tissue becomes greater than the ability of the current to penetrate it, no further damage occurs (see Figure 6). Increasing levels of power also tend to increase the degree of tissue damage, with increasing amperage causing more damage than increased voltage. Because current density increases inversely as the square of the radius of the electrode, tissue damage is likely to increase with increasing electrode size.

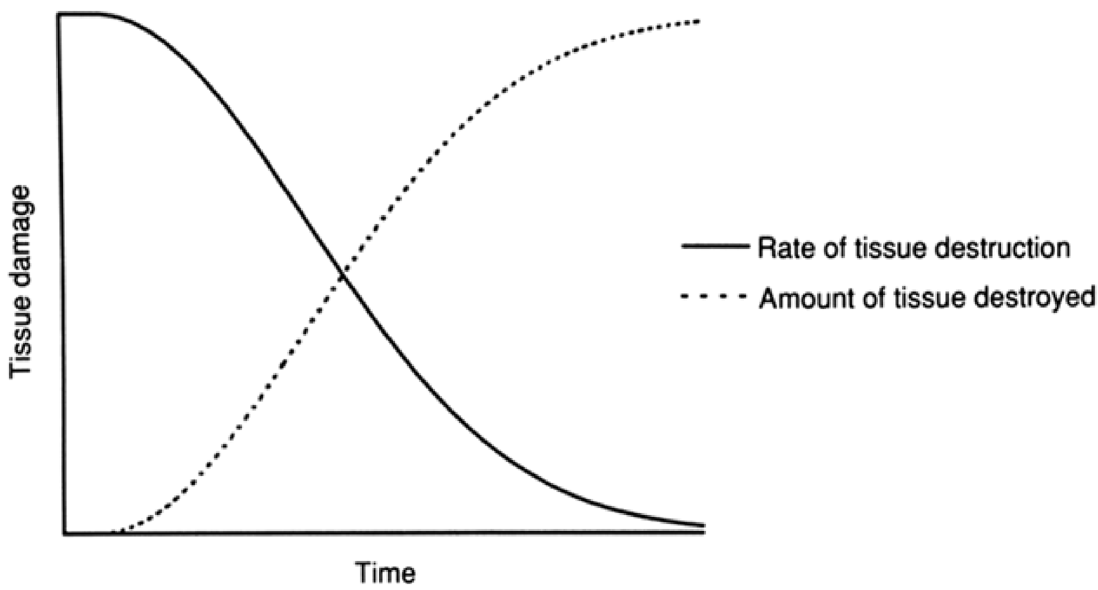


Figure 6 : The relationship between the degree of tissue damage and the rate of tissue destruction: as the amount of damage increases, the rate of destruction slows.

The case of bipolar coagulation deserves special consideration because of its unique features, and widespread use in laparoscopic surgery. Greenwood first described bipolar electrocoagulation in 1940. Ramsay and colleagues found that bipolar coagulation required less power than unipolar, and would operate regardless of the medium in which it was used, permitting coagulation in a fluid environment, a great advantage when attempting to coagulate in a wet field. The main advantage of bipolar coagulation to the gynecologist is its limited spread of electrical effect. Due to the fact that the tissue to be coagulated is nearly, but not entirely, isolated from the rest of the body between the blades of the forceps, the current flow is essentially limited to this area. It must be noted that some current leakage does occur with the use of bipolar forceps, and there is the attendant potential for unintended tissue damage. Because bipolar coagulators require less voltage, there is less likelihood that current will follow unexpected pathways, such as sparking to adjacent structures.

The problem of unintended tissue damage has often been attributed to current's purported tendency to concentrate around, and follow, certain structures such as blood vessels, causing unphysiologic heating and subsequent damage. Our review of the literature found little evidence to support this concept. It must be realized that current will tend to distribute through tissue in such a manner as to minimize the potential difference between the electrodes. In simpler terms, current will follow the path of least resistance. If an alternate parallel pathway is available, which taken together with the first path will lower its resistance, a portion of the current will flow along this alternate path. Because heat is a product of the current and the resistance across which it is flowing, it is unlikely that, assuming an adequate dispersive electrode is used, the current density distant from the treatment electrode would be high enough to cause sufficient temperature elevation to damage the tissue in a location other than at the treatment site. The idea that current sufficient to cause tissue damage could travel preferentially along blood vessels or nerves seems to have little support in the literature. Lounsberry and co-workers found no evidence for electrocoagulation effects following vessels or lymphatics, and in fact found that the cooling of the circulation appeared to have a protective effect.

Even though the reason for the use of radiofrequency current (as opposed to low frequency current) is to avoid stimulation of excitable tissues, particularly nervous tissue and muscle, we have all noted localized contractions when attempting to cut muscle or to coagulate bleeding points on it. This paradox is explained by the observation that, as the duration of the stimulus is decreased (*i.e.,* increasing the frequency of the current), stimulation can still be obtained by increasing the strength (current density) of the stimulus. Thus, high frequency current will cause localized muscle contraction where the current density is high, but generalized muscle contraction will be avoided as the current disperses away from the treatment electrode and the current density drops.

1.4 Effects of Electrocautery on Electrosurgery

Electrosurgical process which is operated by surgeon has certain effects on tissue. There are also other factors that could change these effects. These factors listed below;

- ✓ Period
- ✓ Tissue
- ✓ Strength
- ✓ Electrode

1.4.1 Period

The period in which the active electrode would be in use directly affects the tissue effect. As the period longer, there would be destruction of tissue in wider and deeper means. However, if the period would be shorter than required, desired surgical result cannot be obtained.

1.4.2 Tissue

The resistance of tissue obstructs electrosurgery current to create a circuit. It is expected that a patient with a muscular body transmit electrosurgical current better compared to patients with low weight or those who has obesity problems.

1.4.3 Strength

The strength level that is chosen by surgeon would determine tissue effect. It is important to pay attention on the fact that the lowest strength level should be chosen in order to obtain required tissue effect. Level of strength would be different according to patient; patients with muscular body, normal height and weight could be treated with lower level of strength compared those with lower weight or obesity problems.

1.4.4 Electrode

The size of the active electrode would directly effect the tissue of the generator effect. Since larger electrode would distribute the current to a wider area compared to smaller electrode, it would need more power. The surgeon should choose the smallest electrode in order to obtain required tissue effect. The same ratio of power use is also valid for dirty and clean electrode as well. The edge points of electrodes could get dirty very easily and could be carbonized. Because of that reason during the operation electrodes should be cleaned very often, beside that manufacturer firms should manufacture teflon covered electrodes in order to make them stay more clear.

CHAPTER TWO

ELECTROSURGICAL UNIT

2.1 Definition and Features of Electrosurgical Unit

Electric devices to assist in surgical procedures by providing cutting and hemostasis (stopping bleeding) are widely applied in the operating room. These devices are also known as electrocautery or surgical diathermy apparatuses. They can be used to incise tissue, to destroy tissue through desiccation, and to stop bleeding by causing coagulation of blood. The process involves the application of an RF spark between a probe and tissue to cause localized heating and damage to that tissue.

The basic electrosurgical unit is shown in figure 7 (Gerhard, 1988). The high-frequency power needed to produce the spark comes from a high-power high-frequency generator. The power to operate the generator comes from a power supply, the output of which may in some cases be modulated to produce a waveform more appropriate for particular actions. In this case, a modulator circuit controls the output of the generator. The application of high-frequency power from the generator is ultimately controlled by the surgeon through a control circuit, which determines when power is applied to the electrodes to carry out a particular action. Often the output of energy from the high-frequency generator needs to be at various levels for various jobs. For this reason, a coupling circuit is inserted between the generator output and the electrodes to control this energy transfer.

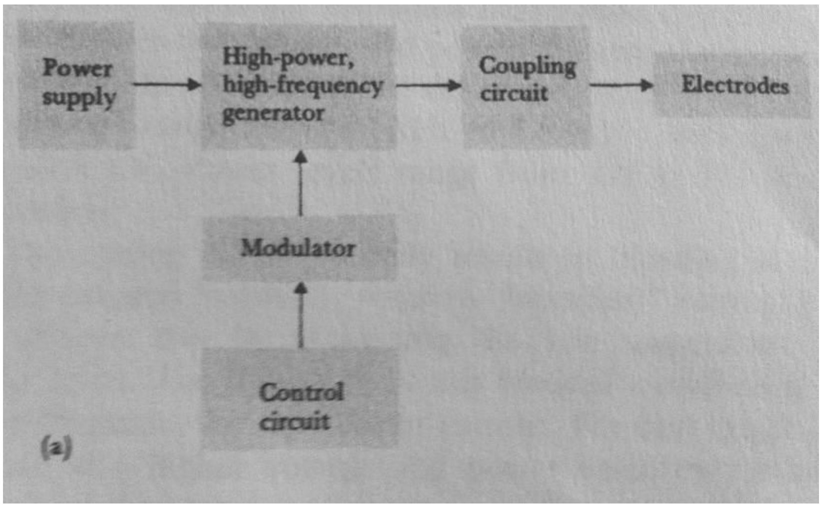


Figure 7: Block diagram for an electrosurgical unit. High-power, high-frequency oscillating currents are generated and coupled to electrodes to incise and coagulate tissue.

The electric waveforms generated by the electrosurgical unit differ for its different modes of action. To bring about desiccation and coagulation, the device uses damped sinusoidal pulses, as shown in figure 8. The RF sine waves have a nominal frequency of 250 to 2000 KHz and are usually pulsed at a rate of 120 per second. Open-circuit voltages range from 300 to 2000 V, and power into a 500-Ω load ranges from 80 to 200 W. The magnitude of both voltage and power depends on the particular application.

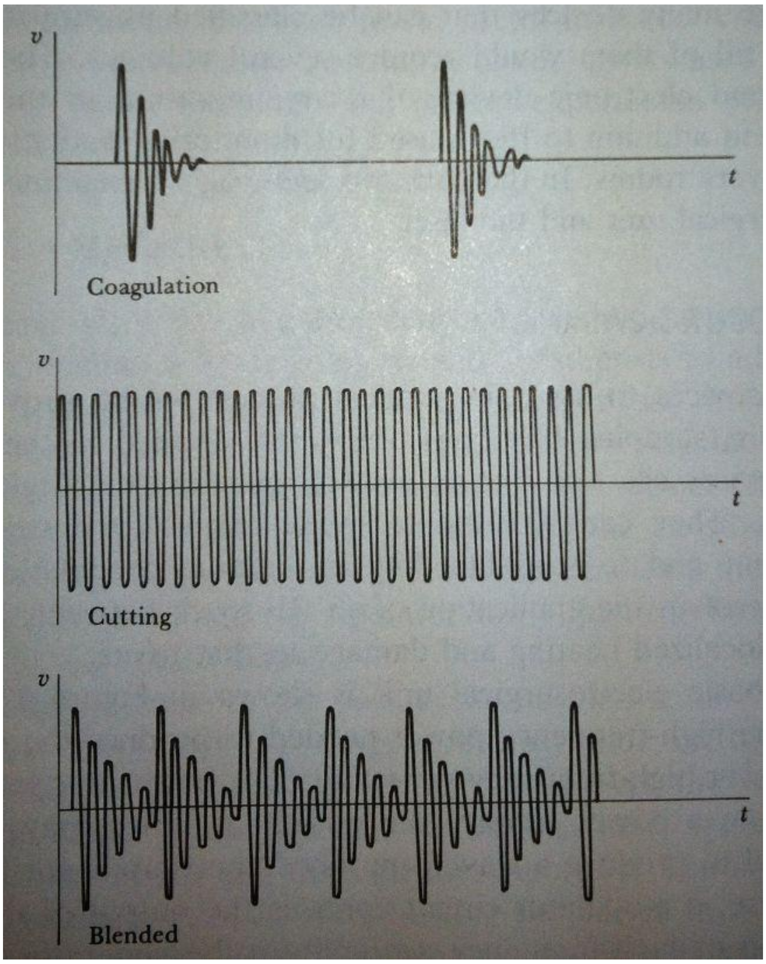


Figure 8: Three different electric voltage wave forms available at the output of electrosurgical units for carrying out different functions.

Cutting is achieved with a CW RF source, as shown in figure 8. Often units cannot produce truly continuous waves, as shown in figure 8 and some amplitude modulation is present. Cutting is done at higher frequency, voltage and power, because the intense heat at the spark destroys tissue rather than just desiccating it, as is the case with coagulation. Frequencies are range from 500 KHz to 2.5 MHz, with open-circuit voltages as high as 9 KV. Power levels range from 100 to 750 W, depending on the application.

The cutting current usually results in the bleeding at the site of incision, and the surgeon frequently requires “bloodless” cutting. Electrosurgical units can achieve this by combining the two waveforms, as shown in figure 8. The frequency of this blended waveform is generally the same as the frequency for the cutting current. For best result, surgeons prefer to operate at a higher voltage and power when they want bloodless cutting than when they want cutting alone.

The merits of various types of electrosurgical units have been reviewed, and the operating characteristics of several commercially available units have been evaluated (Rioux and Yuzpe, 1975).

Many different designs for electrosurgical units have evolved over the years. Modern units generate their RF waveforms by means of solid-state electronic circuits. Older units were based on vacuum tube circuits and even utilized a spark gap to generate the waveforms shown in figure 8.

A block diagram of typical electrosurgical unit is shown in figure 9. The RF oscillator provides the basic high-frequency signal, which is amplified and modulated to produces the coagulation, cutting and blended waveforms. A function generator produces the modulation waveforms according to the mode selected by the operator. The RF power output is turned on and off by means of a control circuit connected either to a hand switch on the active electrode or to a foot switch that can be operated by the surgeon. An output circuit couples the power generator to the active and dispersive electrodes. The entire unit derives its power from a power-supply circuit that is driven by the power lines.

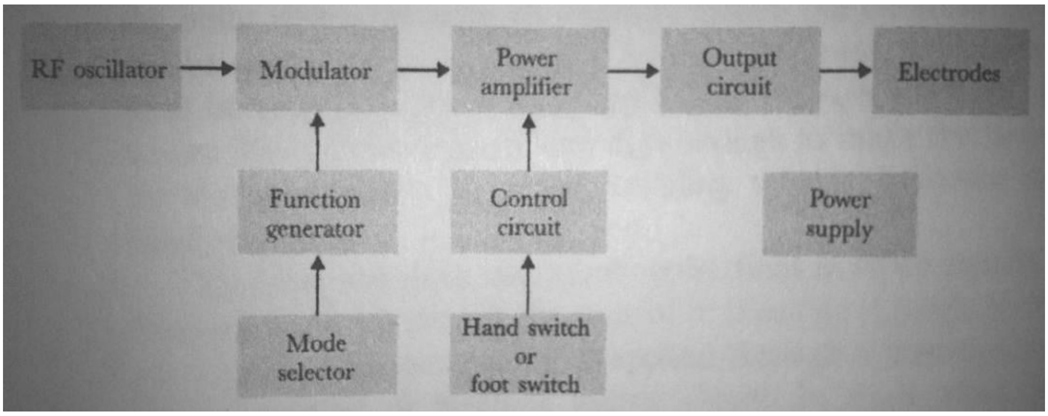


Figure 9: Block diagram of a typical electrosurgical unit.

Electrodes used with electrosurgical units come in various sizes and shapes, depending on the manufacturer and the application. The active electrode is scalpel-like probe that is shaped for the function for which it is intended. The simplest form consists of a probe that appears to be similar to a test probe used with an electronic instrument such as a multi-meter or an oscilloscope. A pointed metallic probe fits into an insulating handle and is held by the surgeon as one would hold a pencil. The hand switch located on the handle is momentarily depressed when the surgeon wants to apply power to the probe.

Whereas the purpose of the active probe is to apply energy to the local tissue at the tip of the probe and thereby to effect coagulation, cutting, or both, the dispersive electrode has a different function. It must complete the RF circuit to the patient without having current densities high enough to damage tissue. The simplest dispersive electrode is a large, reusable metal plate placed under the buttocks or back of the patient. Most procedures use a 70-cm^2 disposable dispersive electrode placed on the thigh. One type is like a disposable ECG electrode with a gel-soaked sponge backed by metal foil and surrounded by foam and pressure-sensitive adhesive. Another capacitive type has a thin Mylar insulator backed by foil ad its entire face coated with pressure-sensitive adhesive. It is important that this electrode make good contact with the patient over its entire surface so that “hot spots” do not develop.

CHAPTER THREE

SOFTWARE AND HARDWARE

3.1 Project Software

The project consists of a hardware unit and software. The hardware is based on using a low-cost PIC microcontroller and an LCD. The software language that used in the project is based on the Proton IDE. Proton IDE is a professional and powerful visual Integrated Development Environment (IDE) which has been designed specifically for the Proton Plus compiler. Proton IDE accelerates product development in a comfortable user environment without compromising performance, flexibility or control. The listing of the program code is shown in appendix B.

3.2 Hardware Component and Simulation

The components that are used in the project are given below:

1 piece of foot pedal (cutting and coagulation pedals.)

- 1 piece PIC16F628
- 1 piece 4 MHz crystal
- 2 pieces of 22 pF capacitor
- 6 pieces 10K resistant
- 1 piece U7805 regulator
- 1 piece 2x16 LCD
- 1 piece button
- 1 piece 9V battery
- 2 sub pedal (in case of need, to use in counter)

3.3 Block Diagram

While the foot pedal is pressed, the circuit is activated. Foot pedal has a parallel connection both to the electrocautery device and to the counter device designed by the author. While the foot pedal is pressed, both microprocessor and electrocautery device are activated. When Pedal 1 is pressed, information is transmitted to the microprocessor which starts to count and display results on the first row of the LCD. At the same time electrocautery device starts to cut process.

When Pedal 2 is pressed, information is transmitted to the microprocessor which starts the count for the second row of the LCD. At the same time electrocautery device starts to coagulation process.

In the circuit, power supply (battery) feed the circuit components with 9V. The battery output 9V goes to the input of a regulator. Regulator regulates the input voltage and converts to 5V, required for all parts of the circuit.

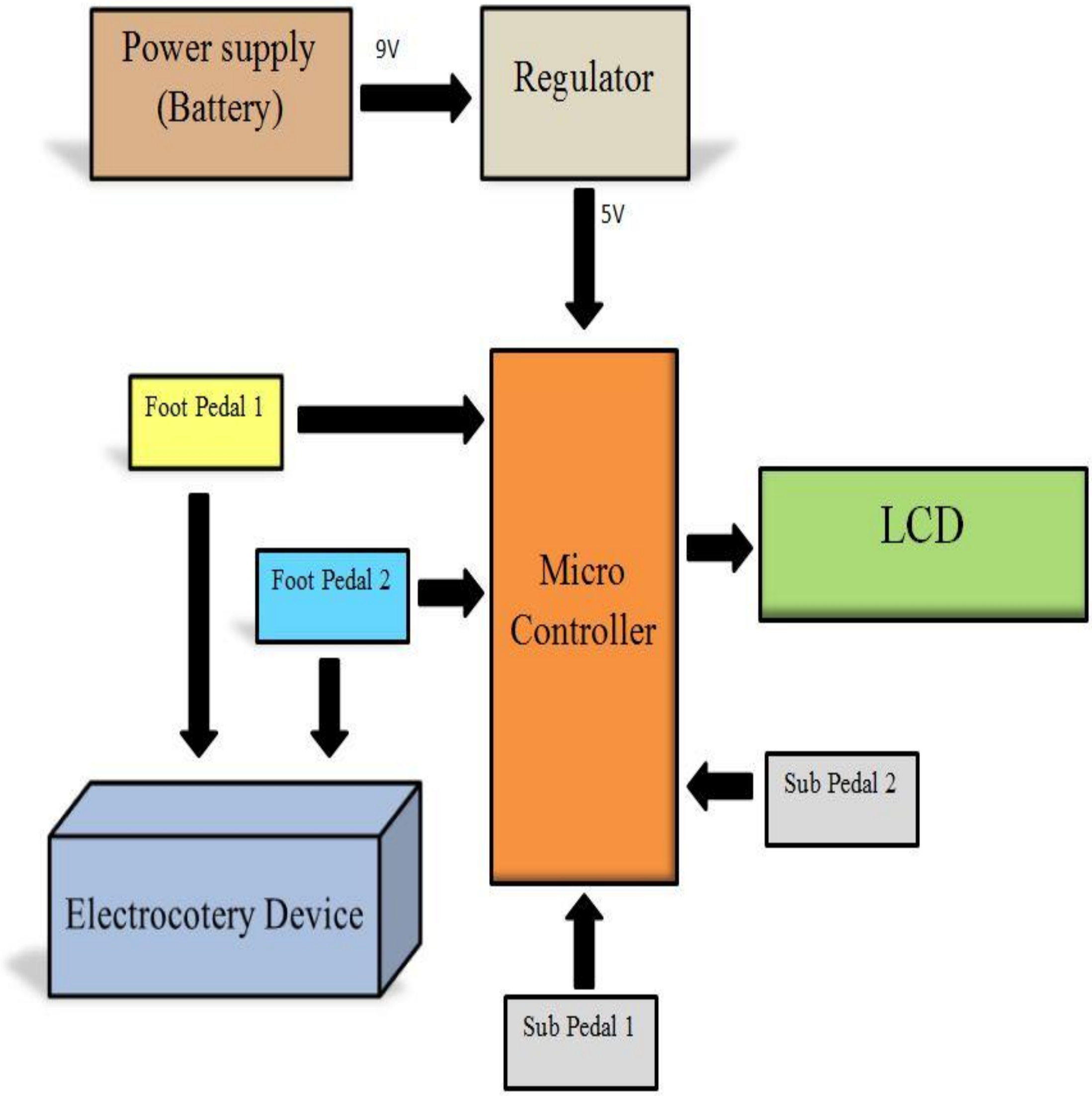


Figure 10: Block diagram of the project.

CONCLUSION

The operation of the circuit was simulated using the Proteus microcontroller simulation software. The results were satisfactory and the simulation showed that the circuit diagram and the software program were operating correctly. After this, the hardware was designed and the program memory of the PIC microcontroller was loaded with the program.

Four different images were displayed on LCD screen, corresponding to pressing four pedals (only two pedals were used in the project). The upper line of the LCD showed the duration of cutting and coagulation.

Two additional pedals (sub pedals) could be used to define the situations different to cutting and coagulation processes during the operation. The indicators that show the commands of those pedals are showed in the lower line of the LCD.

When one of the pedals is active (in use) the other pedals cannot send any commands to the microcontroller, and in that case only the chronometer of the active pedal keeps on counting. When the user stops pressing the pedal, the last value on the screen remains still.

When the user wants to clear the screen by resetting it, he or she has to push the green button on the right hand side of the device twice in order to reset the displayed values.

APPENDICES

Appendix A: Images of the Project

Figure 11: Counter and pedals.

Figure 12: Image of start of counter.

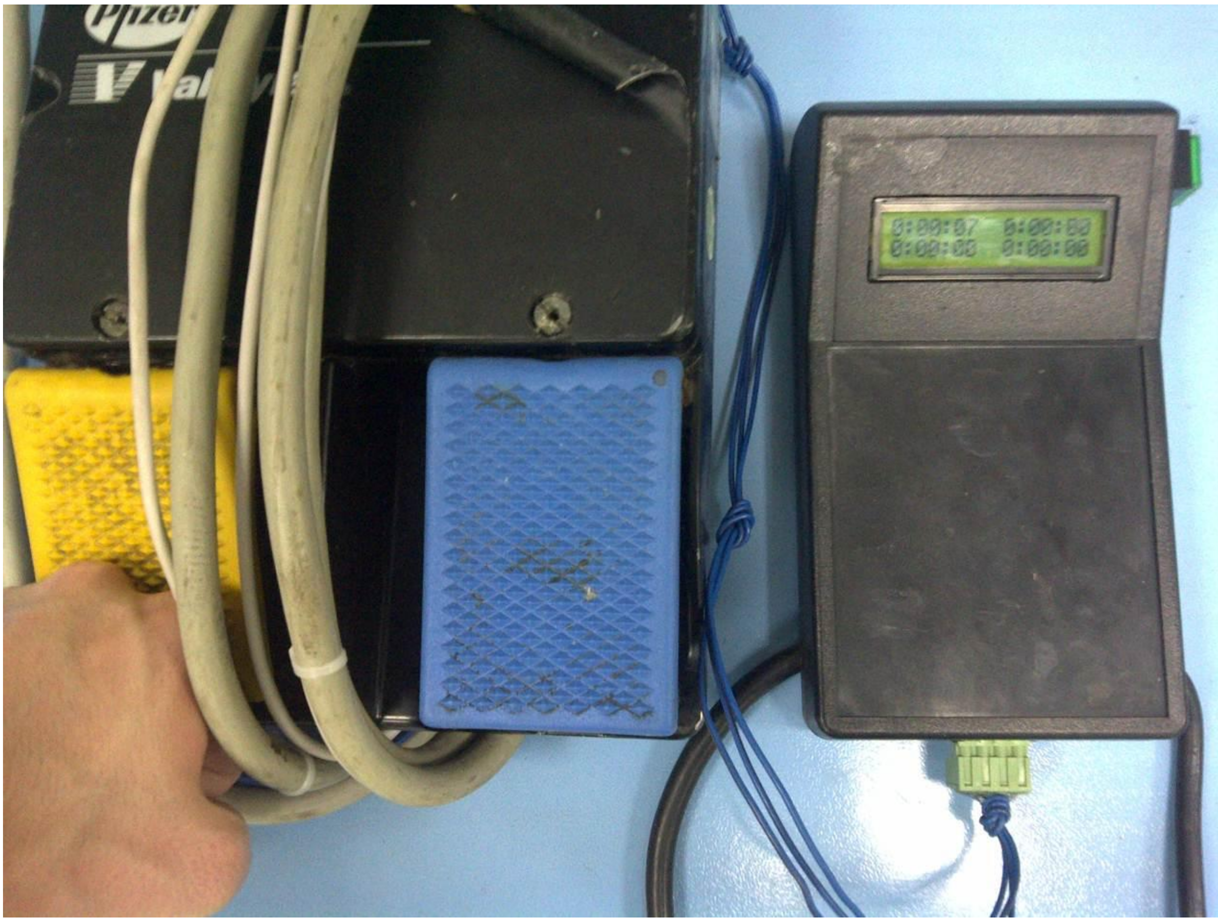
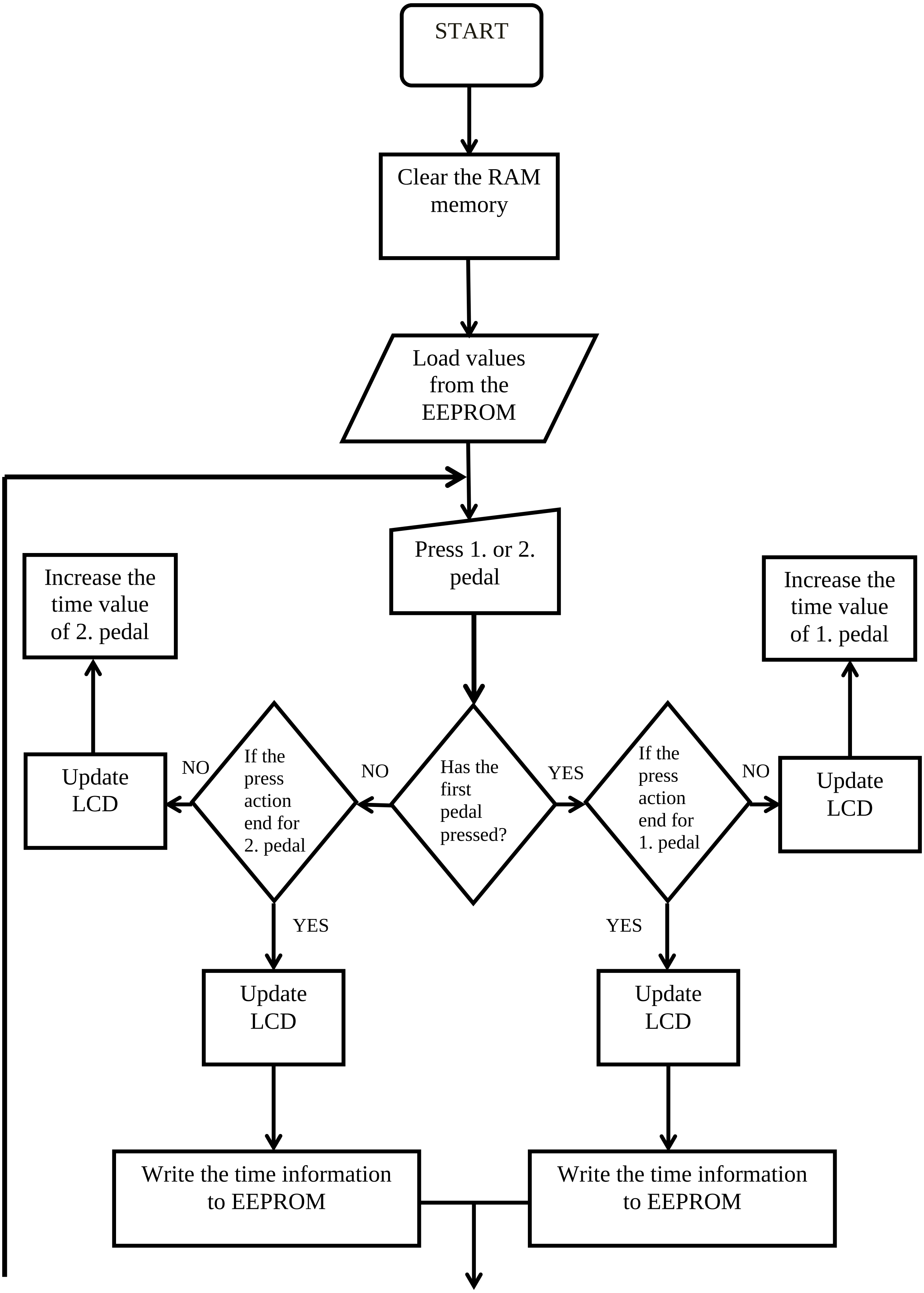
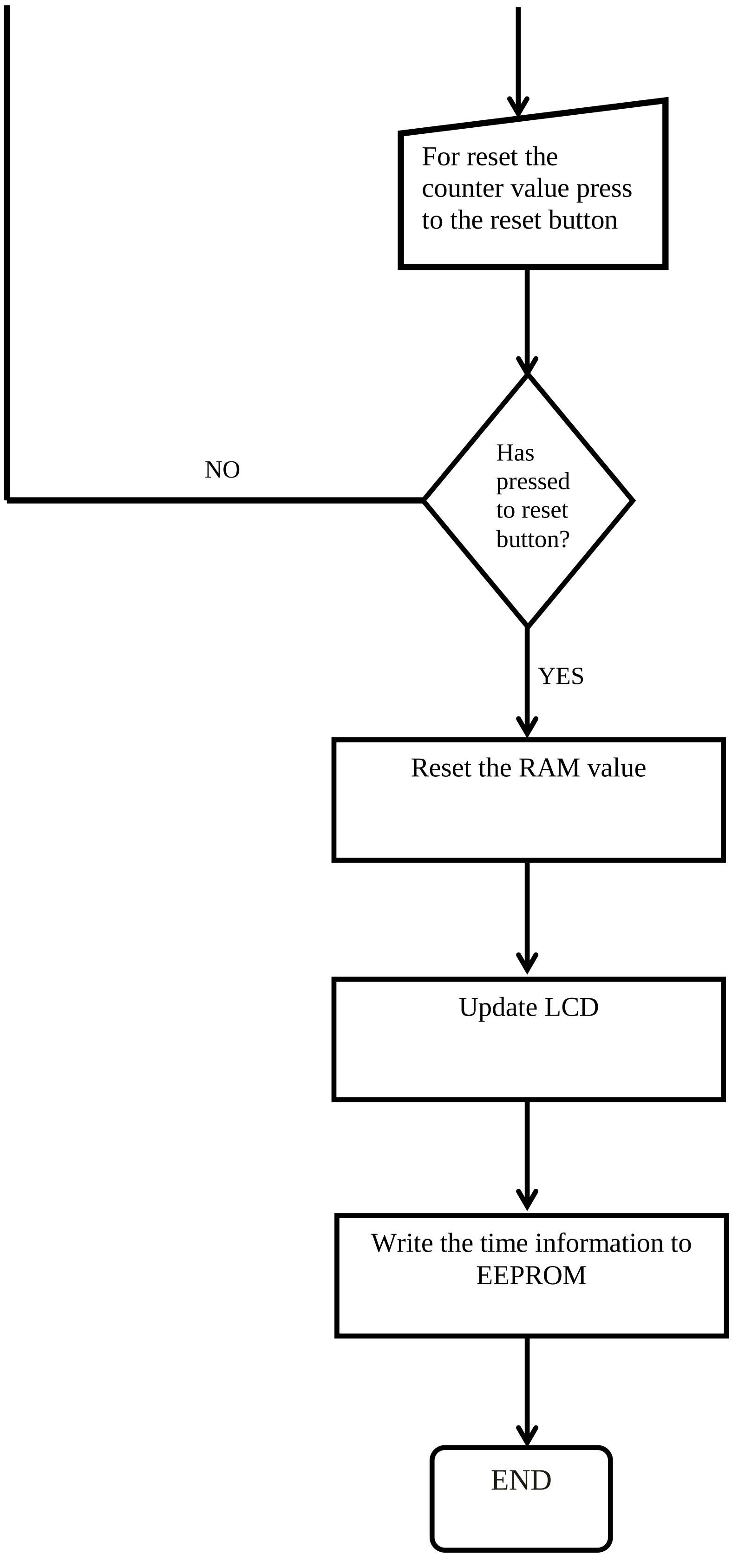


Figure 13: Image of electrocautery cutting pedal (yellow one).

Figure 14: Image of electrocautery coagulation pedal. (Blue one).

Appendix B: Flow Chart




For reset the counter value press to the reset button
NO
Has pressed to reset button?
YES
Reset the RAM value
Update LCD
Write the time information to EEPROM
END

Appendix C: Codes of the Project

```
Device=16F628A
Config BODEN_ON, CP_ON, DATA_CP_ON, PWRTE_ON, WDT_OFF, LVP_OFF,
MCLRE_OFF, XT_OSC
Declare CCP1_Pin PORTB.3

Xtal=4

On_Interrupt GoTo CUTTING

All_Digital=TRUE

TRISB=0
TRISA=$FF

OPTION_REG=%11000111
INTCON=%00100000

Declare LCD_Type ALPHA
Declare LCD_DTPin PORTB.4
Declare LCD_ENPin PORTB.2
Declare LCD_RSPin PORTB.3
Declare LCD_Interface 4
Declare LCD_Lines 2

Dim Sa1 As Byte      'YELLOW CUTTING
Dim Dk1 As Byte
Dim Sn1 As Byte
Dim mSn1 As Word
Dim uSn1 As Word

Dim Sa2 As Byte      'BLUE COAGULATION
```

```
Dim Dk2 As Byte
Dim Sn2 As Byte
Dim mSn2 As Word
Dim uSn2 As Word

Dim Sa3 As Byte         'Pedal1
Dim Dk3 As Byte
Dim Sn3 As Byte
Dim mSn3 As Word
Dim uSn3 As Word

Dim Sa4 As Byte         'Pedal2
Dim Dk4 As Byte
Dim Sn4 As Byte
Dim mSn4 As Word
Dim uSn4 As Word


Dim I As Byte
Dim Temp As Byte

Clear

For I=0 To 27
   Temp=ERead I
   If Temp=$FF Then
      EWrite I, [0]
   EndIf
Next

uSn1=ERead 5

Sa2=ERead 7
Dk2=ERead 8
```

```
Sn2=ERead 9
mSn2=ERead 10
uSn2=ERead 12

Sa3=ERead 14
Dk3=ERead 15
Sn3=ERead 16
mSn3=ERead 17
uSn3=ERead 19

Sa4=ERead 21
Dk4=ERead 22
Sn4=ERead 23
mSn4=ERead 24
uSn4=ERead 26

DelayMS 50

Print At 1,1,"     NEU      "
Print At 2,1," 20082236      "
DelayMS 2500

Call LCD
'----------------------------------------MAIN FUNCTION---------------------------------
MAIN:

If PORTA.0=1 Then
If PORTA.1=0 Then
  Call Cutting_Active
  While PORTA.0=1
      Call LCD
  Wend
  bcf INTCON.7
  Call LCD
```

```
  Call Yaz
EndIf
EndIf

If PORTA.1=1 Then
If PORTA.0=0 Then
  Call Cutting_Active
  While PORTA.1=1
      Call LCD
  Wend
  bcf INTCON.7
  Call LCD
  Call Yaz
EndIf
EndIf
  Wend
  bcf INTCON.7
  Call LCD
  Call Yaz
EndIf

If PORTA.4=0 Then
  Call Cutting_Active
  While PORTA.4=0
      Call LCD
  Wend
  bcf INTCON.7
  Call LCD
EndIf

If PORTA.2=1 Then

  Print At 1,1, "Sifirlamak icin "
  Print At 2,1, "Tekrar onaylayin"
```

```
  DelayMS 30

  While PORTA.2=1
  Wend

  DelayMS 30

  For Temp=0 To 255
      If PORTA.2=1 Then
         GoTo Sil
      EndIf
      DelayMS 4
  Next
Sil2:
  Call LCD

  DelayMS 30

  While PORTA.2=1

  Wend

  DelayMS 30

EndIf

GoTo MAIN
'____________________________________________________________________________________________

'-------------------------------LCD-------------------------------------
LCD:
```

```
Print At 1,1, Dec1 Sa1, ":", Dec2 Dk1, ":", Dec2 Sn1, "  ", Dec1 Sa2, ":", Dec2 Dk2,
":", Dec2 Sn2

Return
'____________________________________________________________________________
_______________

'---------------------------------CUTTING ACTIVE---------------------------------------
Cutting_Active:
  bcf INTCON.2
  clrf TMR0
  bsf INTCON.7
Return
'____________________________________________________________________________
_______________

'--------------------------------EEPROM-----------------------------------
Yaz:
EWrite 0, [Sa1, Dk1, Sn1, mSn1, uSn1, Sa2, Dk2, Sn2, mSn2, uSn2, Sa3, Dk3, Sn3,
mSn3, uSn3, Sa4, Dk4, Sn4, mSn4, uSn4]
Return
'____________________________________________________________________________
_______________

Sil:
Sa1=0
Dk1=0
Sn1=0
mSn1=0
uSn1=0
Sa2=0
Dk2=0
Sn2=0
mSn2=0
```

```
uSn2=0
Dk3=0
Sn3=0
mSn3=0
uSn3=0
Sa4=0
Dk4=0
Sn4=0
mSn4=0
uSn4=0
Call Yaz
Temp=254
GoTo Sil2

'----------------------------------CUTTING-----------------------------------
Disable
CUTTING:
bcf INTCON.2
bcf INTCON.7

If PORTA.0=1 Then                'YELLOW CUTTING
If PORTA.1=0 Then
  uSn1=uSn1 + 536
  mSn1=mSn1 + 65



    mSn1=mSn1 + 1
    uSn1=uSn1 - 1000

    If mSn1>999 Then

      incf Sn1
      mSn1=mSn1 - 1000
```

```
        If Sn1>59 Then

          incf Dk1
          Sn1=Sn1 -60

          If Dk1>59 Then

            incf Sa1
            Dk1=Dk1 -60

            If Sa1>9 Then

              Sa1=0

          EndIf

        EndIf

      EndIf

    EndIf
  EndIf
  EndIf

  If PORTA.1=1 Then           'BLUE COAGULATION
  If PORTA.0=0 Then
    uSn2=uSn2 + 536
    mSn2=mSn2 + 65

    If uSn2>999 Then

      mSn2=mSn2 + 1
      uSn2=uSn2 - 1000
```

```
      If mSn2>999 Then

        incf Sn2

        If Sn2>59 Then

          incf Dk2
          Sn2=SN2-60

          If Dk2>59 Then

            incf Sa2
            Dk2=Dk2 -60

            If Sa2>9 Then

              Sa2=0

            EndIf

          EndIf

        EndIf

      EndIf

    EndIf
  EndIf
  EndIf

  If PORTA.3=0 Then           'Pedal

    uSn3=uSn3 + 536
    mSn3=mSn3 + 65
```

```
If uSn3>999 Then

  mSn3=mSn3 + 1
  uSn3=uSn3 - 1000

  If mSn3>999 Then

    incf Sn3
    mSn3=mSn3 - 1000

    If Sn3>59 Then

      incf Dk3
      Sn3=SN3-60

      If Dk3>59 Then

        incf Sa3

        If Sa3>9 Then

          Sa3=0

        EndIf

      EndIf

    EndIf

  EndIf

EndIf
```

```
EndIf

If PORTA.4=0 Then               'Pedal

  uSn4=uSn4 + 536
  mSn4=mSn4 + 65

  If uSn4>999 Then

    mSn4=mSn4 + 1
    uSn4=uSn4 - 1000

    If mSn4>999 Then

      incf Sn4
      mSn4=mSn4 - 1000

      If Sn4>59 Then

        incf Dk4
        Sn4=SN4-60

        If Dk4>59 Then

          incf Sa4
          Dk4=Dk4 -60

          If Sa4>9 Then

            Sa4=0

          EndIf

        EndIf
```

EndIf

EndIf

EndIf

EndIf

Context Restore

Enable

'

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